Herc SAR Task 112: AIMSsim Visual Target Identification Cues

Final Report

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Defence R&D Canada – Toronto

Contract Report

DRDC Toronto CR 2007-079
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Abstract

CAE Professional Services added a visual cuing capability to the search and rescue Advanced Integrated Multi-sensing Surveillance (AIMS) simulation's sensor displays, as a first step towards the simulation of automated target detection in the AIMSsim. This visual cuing capability will be used in future Defence R&D Canada – Toronto investigations of human factors issues with automated target detection algorithms. Three types of cues were added: bounding box, image overlay, and inverted color in such a way that the new functionality could be integrated to the main development branch of the system and support extendibility. In addition, CAE Professional Services examined how Defence R&D Canada – Toronto incorporated a third-party mosaicing library to AIMSsim in the fall of 2006. Recommendations for properly completing the integration of the mosaicing library into AIMSsim were made.

Résumé

CAE Services professionnels a ajouté une capacité de signalisation visuelle aux affichages des capteurs de simulation du système multicapteur intégré de pointe pour la surveillance (AIMS) de recherche et sauvetage (SAR), comme première étape vers la simulation de détection automatisée de cibles dans le système AIMSsim. Cette capacité de signalisation visuelle servira dans les futures études des questions de facteurs humains menées par R & D pour la défense Canada – Toronto à l'aide d'algorithmes de détection automatisée de cibles. Trois types de repères ont été ajoutés : un cadre englobant, la surimposition d'image et l'inversion de couleurs, de sorte que la nouvelle fonctionnalité puisse être intégrée au principal embranchement de mise au point du système et prendre en charge l'extensibilité. En outre, CAE Services professionnels a examiné de quelle façon R & D pour la défense Canada – Toronto a intégré une bibliothèque de mosaïquage d'un tiers à AIMSsim à l'automne 2006. Des recommandations ont été présentées en vue de l'achèvement approprié de l'intégration de la bibliothèque de mosaïquage à AIMSsim.This page intentionally left blank.

Executive Summary

Herc SAR Task 112: AIMSsim Visual Target Identification Cues

Oliver Schoenborn and Nima Bahramifarid; DRDC Toronto CR 2007-079; Defence R&D Canada – Toronto; April 2007.

Background

This document is the final report for Herc-SAR Task 112 – AIMSsim. This work was a short-term Firm Fixed Price contract starting Feb 13th and ending Mar 31st, 2007. The objective of the project was to incorporate visual cues for automatic target detection simulation in the AIMSsim software, to determine the problems preventing the integration of the Mosaicing library provided to CAE PS by the client and to provide an estimate of the level-of-effort that would be required to fix the problems.

Results

The deliverables for this task were the updated software in source and executable forms, and this final report, all on CD. The final report will be sent as hardcopy along with the CD. Bounding box, image overly, and inverted colour cues were incorporated into the system as per the SOW. The level of effort required for integrating the Mosaicing library is on the order of several weeks, due to several factors: the need to replace DRDC's raw OpenGL API calls into proper OpenSceneGraph instances and calls, the need to properly convert between two coordinate systems, and the absence of proper visual rendering of the desired mosaicing effect.

Future plans

The recommendations for the next phase are to focus on the configurability of the target detection cues and transitioning the OpenGL API calls to OpenSceneGraph.

Sommaire

Tâche 112 du programme Herc-SAR : repères d'identification visuelle des cibles dans le logiciel AIMSsim

Introduction

Le présent document est le rapport final sur la tâche 112 du programme Herc-SAR – logiciel AIMSsim. Le travail a été exécuté en vertu d'un marché à court terme à prix fixe ferme qui a débuté le 13 février et pris fin le 31 mars 2007. Le projet visait l'intégration de repères visuels en vue de la simulation de la détection automatisée de cibles dans le logiciel AIMSsim pour déterminer les problèmes qui empêchaient l'intégration de la bibliothèque de mosaïquage fournie par le client à CAE Services professionnels et fournir une estimation du niveau d'effort requis pour régler les problèmes.

Résultats

Les résultats attendus de cette tâche étaient la mise à niveau du logiciel sous formes première et exécutable, ainsi que la préparation du présent rapport final, le tout sur CD. Le rapport final sera envoyé en version imprimée avec le CD. Les repères de cadre englobant, de surimposition d'image et d'inversion des couleurs ont été intégrés au système, conformément à l'énoncé des travaux (EDT). Le niveau d'effort requis pour l'intégration de la bibliothèque de mosaïquage est de l'ordre de plusieurs semaines, en raison de plusieurs facteurs : le besoin de remplacement des appels API OpenGL bruts de RDDC en instances et appels OpenSceneGraph appropriés, le besoin de conversion appropriée entre deux systèmes de coordonnées et l'absence de rendu visuel approprié de l'effet de mosaïquage désiré.

Recherches futures

À la prochaine phase, il est recommandé de mettre l'accent sur la configurabilité des repères de détection des cibles et le passage des appels API O

Table of Contents

List of Figures

1 Introduction

The Advanced Integrated Multi-sensing Surveillance (AIMS) system was designed to help search and rescue (SAR) operators with their difficult task of detecting and identifying objects of interest, while maintaining situational awareness. Detection and identification are difficult tasks, with low success rates. Crash sites are often found in areas that have already been searched. The AIMS system provides SAR operators with multiple streams of data to aid them, but in the end, detection depends on the operator's ability to interpret this large data set and identify possible targets. One solution to this problem is to implement assisted target detection (ATD) algorithms that will improve human detection rates by using visual cues to draw attention to locations in the data stream where target probability is higher. The goal of the current research is to evaluate the human factors impact on visual attention of various visual cues in the SAR context using the AIMS simulator.

1.1 Background

The AIMS simulator, a port of the Enhanced Low-light Visible and Infrared Surveillance System (ELVISS) prototype to a PC platform, developed by CAE Professional Services (CAE PS, formerly Greenly and Associates, HFR Task 2004-101) provides a cost effective means of evaluating interface design concepts and operator performance using optical imaging system displays. CAE PS is currently supporting the AIMS simulator through HFR Task 2006-111 and has also completed HFR Task 2005-106.

1.2 Objective

The main objective of this call-up was to introduce target-identification display cues into the AIMSsim software, for search and rescue experimentation tasks at DRDC Toronto. A secondary objective was to assess and determine the level of effort (LOE) that would be required to fix the integration problems of the Mosaicing library provided to CAE PS by the client. The deliverables for this task were the updated software in source and executable forms and this final report all on CD. The final report was delivered in hardcopy along with the CD.

1.3 This Document

This document is the final report for *Herc-SAR Task 112: AIMSsim ATD*. Section 2 summarizes the deliverables accompanying this report. Section 3 of this document summarizes the work performed on this tasking. Section 4 makes recommendations for the next phase of work.

2 Deliverables

All the deliverables have been burnt to a CD and sent to DRDC Toronto along with this report. The software binaries have also been uploaded to the DRDC Toronto File Transfer Protocol (FTP) site, and a draft of this report will be sent to the client prior to burning to CD. The CD contains:

- Application:
  - AIMSsim-2_2_3.tar.gz: binaries and experiments
- Source:
  - AIMS-2_2_3-src.zip: latest snapshot of the source code from the version controlled Subversion code repository.
- Documentation:
  - Herc-SAR Task 112 Final Report.pdf
  - AIMSsim_Manual_System_Jul-2007.pdf
  - AIMSsim_Manual_User_Jul-2007.pdf

3 Summary of Work Performed

This section summarizes the work performed under this task. The high level tasks from the Statement of Work (SOW) are as follows:

1. Phase I: incorporate 3 out of 5 visual cues
2. Phase II: assess and provide the LOE required to integrate DRDC's Mosaicing library to AIMSsim

3.1 Phase I: Incorporate 3 out of 5 visual cues

Cue types 1, box (Figure 1), and 2, image overlay (Figure 2) were first integrated to the system. Two different methods were investigated based on requirements for sizing etc. These two methods are described below. In the end only the technique of attaching the cue to the sensor's overlay node was found to be practical, viable and reliable.

The first technique was based on incorporating the cue "object" as a piece of geometry in the world's scenegraph, specifically, attached to a target. This technique required primarily that the cue size and orientation be changed at every frame according to the viewpoint and view direction. The main disadvantage of this technique is that it required taking into account the pixel size of the target on the screen and correlating the specified "size" configuration parameter to the size the cue should be on screen (physical dimension? number of pixels? etc.). Another disadvantage is that the appearance in different sensor displays would be more difficult to control.

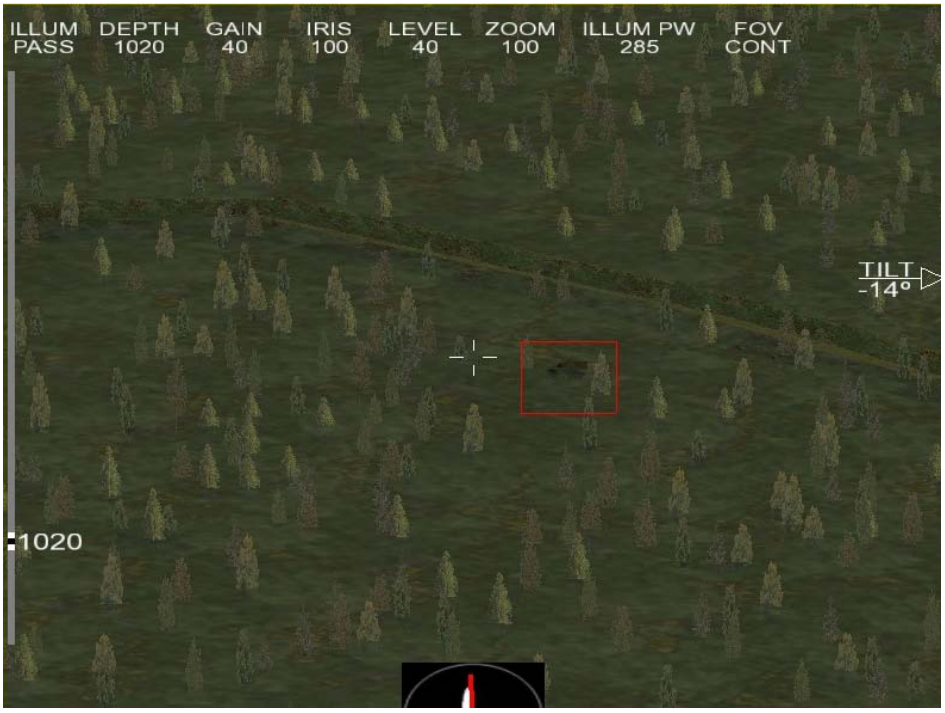

Figure 1: AIMS ATD cue, bounding box type

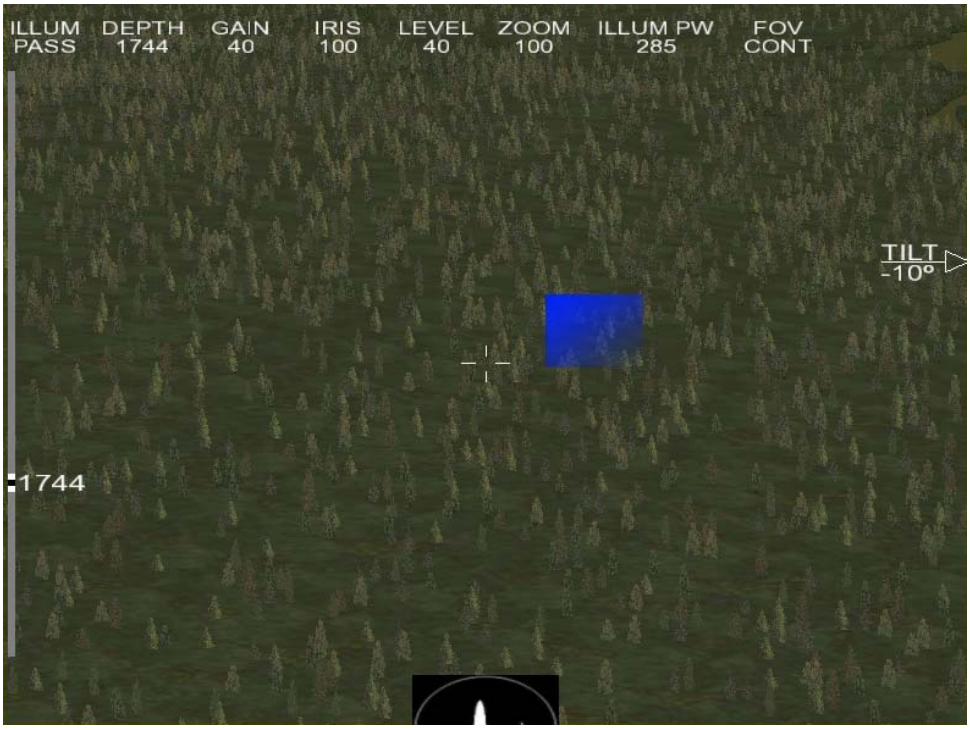

Figure 2: AIMS ATD cue: image overly type

The second technique was based on attaching the cue geometry to the sensor's overlay node. Each sensor has its own overlay plane, which it prefixes to the shared interface. This requires only positioning rather than sizing and orienting, and will allow customizability of cues for each sensor when cues are shown in more than one sensor display (e.g. to show different information, or to maximize the visibility of the cue based on the display characteristics). It also has the advantage that cues can be disabled independently in different sensor displays, and that the cue visibility can be controlled independently of the target visibility. As in the real system, cues are never partially occluded by terrain when using the second technique.

CAE PS modified the system to make cues disappear when the target position is hidden by terrain, using line intersection detection between sensor and target. CAE PS also added the capability to automatically size the cue according to target size at every frame (as a percentage of the bounding sphere radius). This affords the cue to change size with the zoom factor.

Cue type 5, inverted color (Figure 3), was then integrated to the system, based on the work completed for the first two types. This makes use of OpenSceneGraph's support for OpenGL Shading Language programs, via the use of a fragment shader. This shader allows for powerful customization of the image processing desired for the cue and will make implementing cue types 3, pseudo-color, and 4, contrast adjustment, relatively straightforward in follow-on work (using textures to transfer the parameters to the shader, and encoding the corresponding cue type algorithm in the fragment shader). Examples of customization are non-rectangular cue shapes and time-dependent effects (flickering, color changes, etc).

The shader is implemented as the file *atdCues.frag*, which in the source distribution is located in the etc/shaders folder. Note that all shader files are loaded from the *$(AIMS_DATA)/shaders*, so it may have to be copied there. In addition, two new lines had to be added to the *agtv.frag* shader to apply the cue effects to the sensor view.

Note that in the current implementation of the ATD cues fragment shader, only three inverted color cues can be shown. Follow-on work will be necessary to support more. Doubling the number would be straightforward (a day of work), but supporting a large number of them will require more significant changes to the fragment shader file.

The implementation supports partial configurability by allowing the experimenter to change which image should be shown via an environment variable, AIMS_ATD_CUE_IMG. Complete configurability via initialization scripts would have required extending the project beyond March 31st 2007, which was not an option due to budget constraints. More powerful configurability will be implemented in follow-on work, such as controlling the color, thickness, line type (dashed etc), border visibility, and so on, from the experiment's Lua scripts.

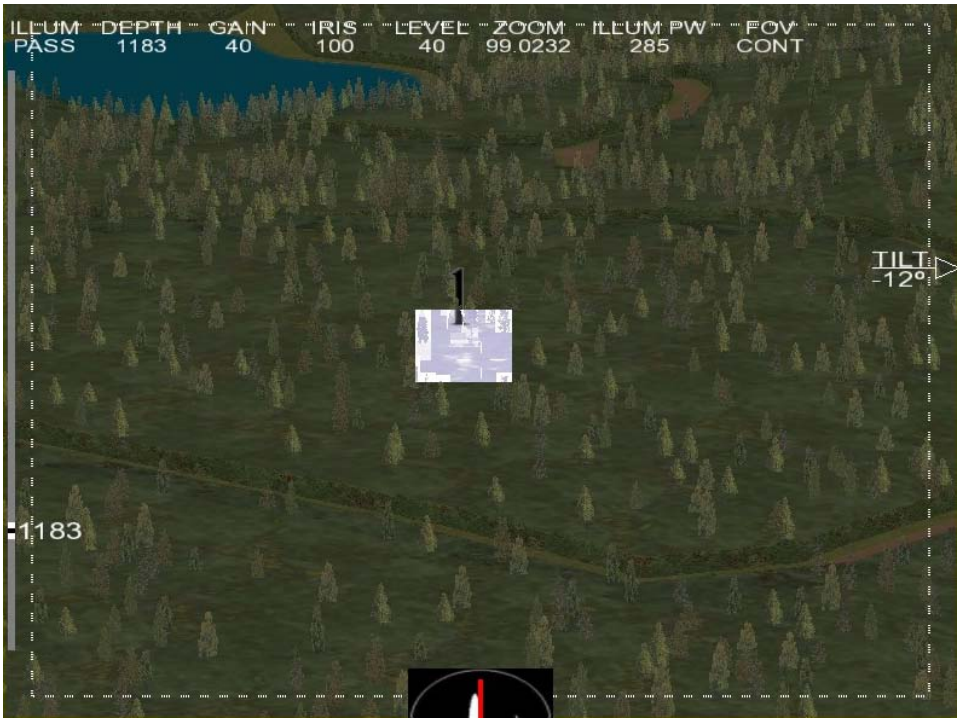

Figure 3: AIMS ATD cue, inverted color type

3.2 Phase II: assess level of effort for mosaicing integration

DRDC Toronto started integrating an in-house mosaicing library, developed by DRDC Valcartier, in the fall of 2006. Some hurdles prevented DRDC from completing the integration. The client asked CAE PS to assess the issues and determine how much effort would be required to complete the integration.

CAE PS took a careful look at the report written by the client, and at the code. Building the system was not within scope of the project, yet it became evident at the very end of the project that the integration was at a much earlier stage than CAE PS had understood. This implied that assessing the level of effort (LOE) for integration completion would require significantly more code analysis than budgeted, and would require building the system so that code could be

commented out and tweaked to observe visual impact. This was, unfortunately, beyond the scope of the project.

The coordinate system mismatch, the least of the issues observed, should be a matter of 2 to 3 days work to fix properly, assuming the problem exists. Again, modifying the code and building would have been necessary to properly assess this.

Another challenge in this work item was that DRDC used a more recent version of an important external dependency, OpenSceneGraph, in the system. The main development branch, in use by all other projects AIMSsim-related projects, uses v1.0 of OpenSceneGraph. Upgrading the main development branch to OpenSceneGraph v1.2 is planned to happen soon, but not immediately.

Due to the above factors, CAE PS estimates that the LOE required to complete the integration of the mosaicing library into AIMSsim will be on the order of several weeks, similar to the Idelix PDT lens integration effort in early 2006. It would require the following tasks:

- Understand the mosaicing library's API; this would require generating a dummy application to show the effect of the library in a simple context, to change parameters etc. and observe visual impact.
- Design the necessary changes to observe the mosaicing in AIMSsim, with the option to disable it altogether, without performance impact to the system, and allow for different kinds of mosaicing algorithms to be used in the future.
- The design to be implemented with iterative testing to ensure the system is performing to specification.

4 Recommendations for the next phase

CAE PS recommends the following work to support target detection cues and mosaicing:

1. Assess the requirement for using the mosaicing library.
2. Complete the integration of mosaicing library into AIMSsim, such that it maintains the robustness and integrity of the current system. This will require either converting the current OpenGL API calls used for mosaicing, to equivalents in OpenSceneGraph v1.2, or starting from scratch with a design that fits in to the OpenSceneGraph framework and AIMSsim architecture.
3. Improve the configurability of the ATD cues.
4. Add the two remaining ATD cues.

5 References

1. Schoenborn, O. (2006). *AIMSsim System Manual (updated July, 2006)*. DRDC Toronto CR 2001-029; Greenley & Associates, Ottawa, Ontario.

2. Schoenborn, O. (2006). *AIMSsim User Manual (updated July, 2006)*. DRDC Toronto CR 2001-030; Greenley & Associates, Ottawa, Ontario.

Annex A: Statement of Work

Advanced Integrated Multi-sensing Surveillance System Assisted Target Detection Cuing

AIMS ATD

Objective

The Advanced Integrated Multi-sensing Surveillance (AIMS) system was designed to help search and rescue (SAR) operators with their difficult task of detecting and identifying objects of interest, while maintaining situation awareness. Detection and identification are difficult tasks with low success rates. Often, crash sites are found in areas that have already been searched. The AIMS system provides SAR operators with multiple streams of data, but in the end detection is dependent on the operator's ability to interpret this large data set for possible targets. One solution to this problem is to implement assisted target detection (ATD) algorithms that will improve human detection rates by using visual cues to draw attention to locations in the data stream where target probability is higher. The goal of the current research is to evaluate the human factors impact on visual attention of various visual cues in the SAR context using the AIMS simulator.

Background

The AIMS simulator, a port of the ELVISS prototype to the PC platform, developed by CAE (formerly Greenly and Associates, HFR Task 2004-101) provides a cost effective means of evaluating interface design concepts and operator performance using optical imaging system displays. CAE is currently supporting the AIMS simulator through HFR Task 2006-111 and has also completed HFR Task 2005-106.

Statement of Work

The contractor will carry out the following modifications to the existing version of the AIMS simulator. All changes will be implemented after consultation with, and approval of the Project Manager. All changes made to the AIMS simulator should be implemented so that any capability, feature, or characteristic currently provided by the system remains intact and functional.

Phase I. Visual Cues for ATD (5 weeks)

Implement visual cues that will be displayed manually through the LUA initialization script or by an ATD algorithm (future work). At least three of the five cues types are to be implemented, two cues are overlaid onto the sensor display and three cues are enhancements to the terrain.

Sensor Display Overlay Cues:

1. Box

   A box displayed around possible targets. The box's size can be fixed in the initialization script or automatically resized to fit around the entire target. The colour (including alpha) and size of the border of the box will be set in the initialization script.

2. Image Overlay

   An image with parameterized alpha channel displayed at the location of the possible target. The image file will be set in the initialization script.

Terrain Enhancement Cues:

3. Pseudo-Colour

   Map the grayscale image of a parameterized area around the potential target to a pseudo-colour image. The pseudo-colour image will make use of a "rainbow" colour palette mapping that will be defined in the initialization script.

4. Contrast Adjustment

   Increase the Michelson contrast of a parameterized area around the potential target. The value of the increased contrast will be set in the initialization script.

5. Inverted Colour

   Invert the colours of a parameterized area around the potential target.

Phase II. Mosaicing Library Review (1 week)

Determine outstanding issues preventing the integration of the mosacing library with the AIMS simulator and provide an estimate for the work yet to be completed.

Security

This project is unclassified. This work will be completed offsite and installed on DRDC Toronto hardware by DRDC personnel.

Schedule

All work must be completed and delivered before March 31 2007.

Government Funded Equipment

- The existing AIMS simulator.
- The current mosaicing implementation into AIMS and associated documentation.

Project Manager

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Recommended Source of Supply

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Sole Source Justification

CAE (formerly Greenly and Associates) developed the AIMS simulator for DRDC Toronto under HFR Task 2004-101. CAE is currently supporting the AIMS simulator through HFR Task 2006-111 and has also completed HFR Task 2005-106.

Budget

This contract will be a call-up under SO W7711-047904/001/TOR. The total cost for this fixed price contract will be $30 000 + GST.

Deliverables

- CD or DVD containing code.
- Soft and hard copies of documentation in DRDC Technical Report format

List of abbreviations/acronyms

AIMS	Advanced Integrated Multi-sensor Surveillance
API	Application Programming Interface
ATD	Assisted Target Detection
CD	Compact Disk
ELVISS	Enhanced Low-light level Visible and Infrared Surveillance System
FTP	File Transfer Protocol
HFR	Human Factors Research
LOE	Level of Effort
PDT	Pliable Display Technology
SAR	Search and Rescue
SOW	Statement of Work

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CAE Professional Services added a visual cuing capability to the search and rescue Advanced Integrated Multi-sensing Surveillance (AIMS) simulation's sensor displays, the first step towards a simulation of automated target detection in AIMSsim. This visual cuing capability will be used in future Defence R&D Canada – Toronto investigations of human factors issues with automated target detection algorithms. Three types of cues were added: bounding box, image overlay, and inverted color in such a way that the new functionality can be integrated to the main development branch of the system and support extendibility. In addition, CAE Professional Services examined how Defence R&D Canada – Toronto incorporated a third-party mosaicing library to AIMSsim in the fall of 2006. Recommendations for properly completing the integration of the mosaicing library into AIMSsim are made.

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AIMS, Assisted Target Detection, Simulator, Cues, Mosaicing, CAE